Naval Submarine Medical Research Laboratory

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MOTOR AND COGNITIVE PERFORMANCE DO NOT CHANGE DURING A TEN-WEEK SUBMARINE PATROL

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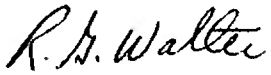

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SUMMARY PAGE

THE PROBLEM

Submariners experience many stresses and changes in their normal lifestyle while on patrol. These stresses may affect performance, vitamin levels, mood, and blood chemistry. This study investigated the effect of vitamin supplementation on performance in submariners before, during, and after a submarine patrol.

THE FINDINGS

There were no changes in performance on tests of motor performance, timed mental arithmetic, digit symbol substitution, or choice reaction time that could be attributed to either the vitamin supplement or to the patrol.

APPLICATION

This study found no significant changes in the cognitive or motor performance of submariners that could be attributed to conditions encountered during a submarine patrol. This finding is in keeping with the Bennett, Schlichting and Bondi (1985) study which also found no changes during the course of a 70 day patrol using two of the same tests. These negative results are in fact encouraging, because they suggest that despite confinement, changes in diet, and marginal vitamin deficiencies, the submariners are still able to perform well and even to improve their performance on some tests during a patrol.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Naval Medical Research and Development Command Research Work Unit 61152N - MR000.01.01-5008. It was submitted for review on 5 October 1989, approved for publication on 22 December 1989, and has been designated as Naval Submarine Medical Research Laboratory Report No. 1150.

ABSTRACT

Submariners experience many stresses and changes in their normal lifestyle while on patrol. These stresses may affect performance, vitamin levels, mood, and blood chemistry. This study investigated the effect of vitamin supplementation on performance in submariners before, during, and after a submarine patrol. While on patrol, half of the subjects were given a vitamin supplement while the other half received a placebo. There were no changes in performance on tests of motor performance, timed mental arithmetic, digit symbol substitution, or choice reaction time that could be attributed to either the vitamin supplement or to the patrol.

INTRODUCTION

While on patrol, the average submariner experiences many stresses and changes to his normal lifestyle. The type of job he is required to perform is very demanding; and he is unable to escape from confinement, potential danger, and separation from family and friends.

Because of watchstanding requirements, the length of his normal "day" is shifted from 24 hours to 18 hours. This shift of diurnal rhythm is further complicated by a lack of full spectrum lighting which is important to the synthesis of Vitamin D.

In addition to these stresses, there are changes in the normal diet. After the first few weeks, there is a lack of fresh fruit, vegetables, and dairy products. There may be changes in protein intake and in the intake of caffeine in coffee, tea, and soft drinks. These changes undoubtedly contribute to the finding that many submariners suffer from marginal vitamin deficiencies during a patrol (1,2). The opportunity to participate in physical exercise is limited. Many of these conditions are known to cause changes in the psychological and physiological functioning of susceptible individuals. Some changes that have been reported include feelings of inadequacy, loss of interest in food, loss of appetite, weight change, agitation, psychomotor retardation, diurnal mood variations, or reduced libido.

A previous study attempted to determine whether there were decrements in cognitive performance during the course of a patrol (3). It investigated cardiorespiratory fitness and cognitive performance during 70 days of confinement in a nuclear submarine. The results showed no decline in performance of mental math and choice reaction time over the course of the patrol. The present study was, therefore, undertaken to study the effects of a submarine patrol on both cognitive and motor performance, and additionally to determine if vitamin supplementation would improve performance that might arise.

METHOD

Subjects: Twenty-two subjects were recruited from the crew of a Fleet Ballistic Missile submarine about to deploy on a three month patrol. The men ranged in age from 18-35. Each subject was given a complete physical prior to acceptance as a subject in the study. Informed written consent was obtained from each subject prior to the actual study. The study was approved by the Committee for the Protection of Human Subjects at NSMRL.

Procedure: To assess cognitive and motor performance, a test battery was used which included mental math, choice reaction time, and digit symbol substitution. All of these tests were presented using an HP-85 portable computer. The motor tests used were pencil and paper versions of steadiness and pursuit aiming.

Each subject participated in ten practice sessions prior to deployment. During the first session the subjects were briefed about the experiment, signed consent forms, and took each of the tests once. Each subsequent session again included all of the tests. Subjects always took the tests in the same order at every session.

During the patrol each subject took the tests once a week for ten weeks. After the subjects had returned to the Naval Submarine Base in Groton, CT, they participated in four post-patrol sessions.

The Tests:

Cognitive Tests: For the mental math, twenty problems were used. Each problem consisted of adding two three-digit numbers and then subtracting a third three-digit number. Over the course of ten practice sessions, the time of presentation of each problem during the patrol was set to equal the average presentation time at which the subject was correct on approximately 60% of the problems.

In the choice reaction time task a single digit (1,2,3, or 4) appeared on the face of the CRT and the subject responded by pressing the appropriate number on the computer keyboard. Twenty trials were used for each session.

The digit symbol substitution test consisted of a pattern of symbols matched to a number. When the number was presented, the subject had to match the pattern using the keypad on the computer. The number of correct matches was scored for a ninety second interval.

Motor Tests: These were two standard paper and pencil versions of pursuit aiming and steadiness. In the pursuit aiming test, the task was to put dots inside small circles on a page covered with the circles. The circles were connected by lines to form horizontal rows of circles. The score was the number of circles in which the subject has placed dots during a one minute period. The steadiness test consisted of a page of 32 sets of two closely spaced three inch horizontal lines. The task was to draw a line between the two lines without touching them. The score was the number of line sets completed in one minute.

Vitamin Supplements and Placebos: Ayerst Laboratories supplied numbered bottles containing either Cluvisal, a nonprescription multivitamin tablet, or a matched placebo. The study was conducted in a double-blind manner: that is, neither the investigators nor the subjects knew which bottles contained placebos and which contained vitamins, until the code was broken at the end of the final data analysis.

A bottle was assigned to each volunteer, and during the patrol each person took one tablet each day. To ensure compliance, the tablets were taken daily, beginning on the first day of the patrol, in the presence of one of the investigators. Eleven subjects received the

vitamin supplement during the patrol, and the other eleven received a placebo. A log of medical or health related problems was also kept for each subject throughout the patrol.

Two mood inventories, the Beck Inventory, and Depression Adjective Check List (DACL), were administered to the subjects prior to the patrol, on a weekly basis throughout the patrol, and thirty days following the patrol. This data is included in the Vitamin B-6 report (2), and will not be discussed in this report.

Blood samples were taken from all subjects to determine vitamin status before during and after the patrol. These samples were analyzed by three separate laboratories, and reports on hematocrits, vitamins B-6 (2), and D (3) have been published separately. Samples destined for analysis of other vitamins and minerals were lost in shipping.

RESULTS

There were no significant changes in any of the performance measures that could be attributed either to an effect of the patrol environment or of vitamin supplementation. The only significant effects were a decrease in the number correct on the choice reaction time task ($F = 8.61(2,32)$, $p < .01$) and a decrease in the mean time taken to complete each problem on the digit symbol substitution test ($F = 8.73(2,32)$, $p < .01$). The latter reflects an improvement in performance due to additional practice on the task. The DSST test showed a significant difference between the two groups which was of the same magnitude throughout the testing ($F = 5.87(1,16)$, $p < .05$).

Table 1 shows the performance for each cognitive test and each group at the end of training (labeled prepatrol), at the end of the patrol, and one month post patrol. Each value is the mean of two sessions. The prepatrol value is the mean of the last two practice sessions. The patrol value is the mean of the last two patrol values, and the post-patrol is the mean of the last two post-patrol sessions.

There were no changes in performance on the two motor tests over the course of the experiment.

Table 1

MENTAL MATH - MEAN TIME in SECONDS (CORRECT PROBLEMS)

	Prepatrol	Patrol	Postpatrol
Vitamin Group	6.16	6.15	6.13
Placebo Group	5.59	5.61	5.36
Mean	5.87	5.88	5.75

MENTAL MATH - MEAN NUMBER CORRECT

Vitamin Group	20.9	21.05	21.65
Placebo Group	21.88	21.88	23.56
Mean	21.39	21.46	22.61

DIGIT SYMBOL SUBSTITUTION TEST - MEAN TIME in SECONDS PER PROBLEM

Vitamin Group	2.26	2.17	2.09
Placebo Group	2.07	2.00	1.96
Mean *	2.16	2.08	2.02

DIGIT SYMBOL SUBSTITUTION TEST - PERCENT OF PROBLEMS CORRECT

Vitamin Group	97.27%	97.87%	97.33%
Placebo Group	97.29	97.48	97.50
Mean	97.28	97.28	97.42

CHOICE REACTION TIME - NUMBER CORRECT

Vitamin Group	19.95	19.40	19.05
Placebo Group	19.50	19.25	19.19
Mean *	19.72	19.32	19.12

CHOICE REACTION TIME - MEAN LATENCY in MSEC. FOR CORRECT RESPONSES

Vitamin Group	552.11	560.23	548.76
Placebo Group	524.40	505.90	509.16
Mean	538.26	533.06	528.96

* $p < .05$

DISCUSSION

This study found no significant changes in the cognitive or motor performance of submariners that could be attributed to conditions encountered during a submarine patrol. This finding is in keeping with the Bennett, Schlichting and Bondi (3) study which also found no changes during the course of a 70 day patrol using two of the same tests. These negative results are in fact encouraging, because they suggest that despite confinement, changes in diet, and marginal vitamin deficiencies (1,2), the submariners are still able to perform well and even to improve their performance during a patrol one test.

The small change in number correct in the reaction time task is accompanied by a decrease in mean reaction time. This difference probably reflects a change in subject's speed/accuracy criteria with speed becoming more important than accuracy as the patrol continued. The improved performance on the Digit Symbol Substitution test suggests that subjects had not reached a performance plateau at the end of the pre-patrol training for this task.

The possibility always exists that subtle changes in performance may still occur and that the tests chosen are not sensitive or reliable enough to pick them up. The tests were chosen on two basis: First, these tests are among those recommended for repeated measures applications based upon task stability and task definition (4), and second, these tests seemed to be the most sensitive in that they show changes in performance at altitude (5), during nitrogen narcosis (6), as the result of administration of psychoactive drugs (7), and during exposure to low levels of toxic agents (8). Given that the tests are sensitive to these manipulations and, in addition, are stable, we feel confident that at least for the abilities that they measure, there are no detrimental effects of living in the submarine environment.

We have shown that timed arithmetic, speed of reactions, motor performance, and visual symbol matching were unaffected during a patrol. The factors assessed by these measures include number facility, fine eye-hand coordination, memory, associative and perceptual speed (4). While not exhaustive, these tasks cover many important aspects of the jobs that a submariner performs.

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